Nugget 2: Putting the Squeeze on Plastics

The production of plastics is an energy intensive process, consuming roughly 40,000 Btu for each pound of plastic generated. About half of this energy is used in producing the raw polymer materials, while the remainder is spent in manufacturing plastic goods from such raw materials. During manufacturing, much of the energy is used to heat the polymers to temperatures high Enough to allow them to melt and flow, typically above 200°C (392°F).

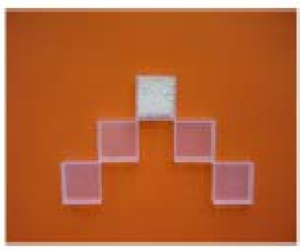

Figure: Core-shell baroplastics processed From powders into rigid box tops at 40°C.

Researchers in MIT's NSF-funded Center for Materials Science and Engineering have developed a new type of plastic that could substantially lower energy consumption related to plastics manufacture. As described in a recent *Nature* article, the new plastics, called ”baroplastics” use similar manufacturing equipment as current commercial plastics but need little or no heating to be molded into desired shapes. Instead, these materials flow when large pressures are applied, due to their specially designed nanophase structure. At microscopic length scales, the raw materials, made by core-shell emulsion polymerization, are arranged like a Tootsie Pop., with a soft polymer center and a hard polymer shell. When placed under pressure, the hard component partially mixes with the soft component, allowing the entire system to flow. Once the pressure is relieved, the plastic rehardens.

Besides saving energy in plastics manufacture, baroplastics can potentially save energy consumed in raw material production, since the new plastics are also highly recyclable. Unlike traditional heat-based processing, which can thermally degrade polymer molecules and incorporated additives, pressure-based processing causes minimal degradation, allowing the new plastics to be molded over and over without changing their molecular structure. The substantial discoloration and loss of mechanical performance that is problematic in current plastics recycling can thus be avoided. MIT researchers have successfully shredded and remolded their materials as many as 10 times.

1. Gonzalez-Leon, J. A., M. H. Acar, S.-W. Ryu, A.-V. G. Ruzette and A. M. **Mayes**, Low- temperature processing of baroplastics by pressure-induced flow, Nature 426, 424-428 (2003).

Nugget 1: The Color of Shock Waves in Photonic Crystals

The ability to significantly change the frequency of light by an arbitrary amount with high efficiency has been a long and challenging problem. Photonic crystals, materials with periodic modulations of index of refraction, provide a powerful new mechanism for controlling the properties of light and hence, are an attractive candidate system for frequency manipulation in ways that are not possible with conventional methods.

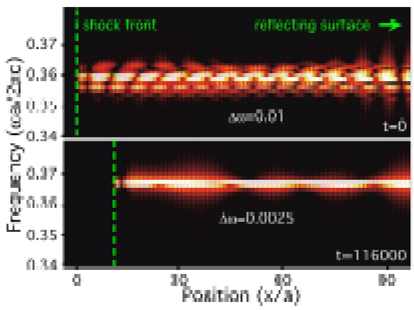

Figure: Light bandwidth narrows when light bounces between an advancing shock front and a mirror at the right-hand boundary of this image. Over the course of the simulation, the shock front moves about 10 pre-shock lattice periods ***a***, and the frequency band is narrowed by about a factor of four. Much higher narrowing factors can be achieved in other scenarios.

In a recent article (Reed, et al., *Phys. Rev. Let*. **90**, 203904, 2003), members of IRG-I report on the discovery of two unexpected and stunning physical phenomena when light reflects from a shock wave that propagates through a photonic crystal (a material that has a periodic modulation of the index of refraction). The first of these new phenomena is the observation of anomalous large "Doppler shifts" in light reflected from the shock wave. These frequency shifts are orders of magnitude larger than normal Doppler shifts and result in color shifts observable with the naked eye. The physical mechanism that gives rise to these frequency shifts is fundamentally new and completely different than existing, known mechanisms like nonlinear frequency conversion. The second new observable effect is the narrowing of the bandwidth of light that reflects from the shock wave with no losses (see Figure). There are many physical systems that increase the bandwidth of light, but to our knowledge, no existing classical systems are capable of narrowing the bandwidth of an arbitrary signal. While these two effects are presented within the context of a shock wave propagating in a photonic crystal, their generality make them

Amenable to observation in a variety of non-destructive and reusable time-dependent photonic crystal systems. These effects could impact technologies ranging from telecommunications to solar power to quantum information processing.

Education Nugget: Science and Engineering Program for Middle School Students

The Center for Materials Science and Engineering at MIT operates a science and engineering program for middle school students from two Cambridge public schools. The objectives of the program are to familiarize the students with materials science and engineering, demonstrate that science is fun and interesting, and introduce students to a college environment. The program consists of a full summer week of hands-on and inquiry-based science and engineering projects for students from each school, who attend with their science teacher. The majority of
Participants are girls or members of underrepresented minority groups. While at CMSE, students explore science and engineering through a variety of hands-on activities developed and taught by faculty, instructional staff, and students. Activities such as glassblowing, metal casting, polymer demonstrations and a shoot-the-hoop. Design contest provide participants with opportunities to learn about different materials and how they are used
In designing and engineering products. CMSE's program for middle school students benefits everyone associated with the program. The science teachers report that their students approach classroom work with increased confidence and enthusiasm. The teachers gather ideas for classroom use and are introduced to other professional development opportunities at the MRSEC. Finally, as they design and teach activities, the MIT students and post-doctoral associates reinforce their own content knowledge and develop stronger communication skills.


Postdoctoral associates and graduate students teach middle school students
About dc motors and polymers.